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ON THE DEPTH OF FORMATION OF LINDHOLM EFFECT

(sur la profondeur de formation de l'effet Lindholm)

(FRANCE)

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[redacted]

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(Presented by Academician Andre Danjon)

The Lindholm effect, or the spectral line shift due to collisions, has the following value :

$$\delta\nu_L = AC^{\frac{2}{5}} p T^{-\frac{2}{5}}, \tag{1}$$

where the signs have their usual meaning.

According to Lindholm there exists a simple relation between $\delta\nu$ and the damping by collision constant γ :

$$\delta\nu_L = 0,36\gamma. \tag{2}$$

The constant γ has been determined by rather imprecise measurements relative to growth curves (see for example Minnaert, reference [2]).

Miss Adam [3] utilized this relation and these determinations, and obtained for $\delta\lambda$ the following values for the iron lines :

Cos θ.	γ(s⁻¹).	δλ(Å).
1,00	0,83.10¹⁰	0,0041
0,20	0,36 »	0,0018
0,15	0,26 »	0,0013

This determination invites criticism because of the lack of precision of determinations, and since the relation of proportionality [1] is only approximate because of the role of damping by radiation which is adding to that of collision, and which is not dependent upon the pressure. This must lead to the conclusion that the values of Miss Adam are overestimated.

However, a precise calculation of the Lindholm effect is necessary on account of its role in the variation of spectrum line wavelengths measured by Miss Adam between the center and the edge of the solar disk, which is precisely due to the combination of the effects Einstein (gravitational displacement), Lindholm (collision effect), and Doppler-Fizeau (motions of the matter).

The important problem from the standpoint of the knowledge of the Sun being the determination of the field of velocities, it is essential to make the exact correction of observations of Einstein effects (which is easy), and of those of Lindholm.

In order to calculate the Lindholm effect, the author solved the problem of transfer in the solar atmosphere for a line, whose absorption coefficient is shifted in frequency of a quantity $\delta\nu_1$ defined by the equation (1), and therefore variable with the depth (fig.1). This problem is similar to that of line formation in the Cepheid spectrum, or to that of transfer in the vicinity of sunspots, taking into account the Evershed effect, variable with depth.

The equation utilized is the following

$$\delta I = I_{R_0} - I_{R_\nu} = \int_0^\infty B(T(\tau_0))\, e^{-\tau_{R_0}} \left[1 - \frac{\varkappa_{R_\nu}}{\varkappa_{R_0}} e^{\tau_{R_0} - \tau_{R_\nu}} \right] d\tau_{R_\nu},$$

where the annotations are standard.

The Lindholm effect intervenes in the computation of τ_{R_ν}. This is the way the points of figure 2 were obtained.

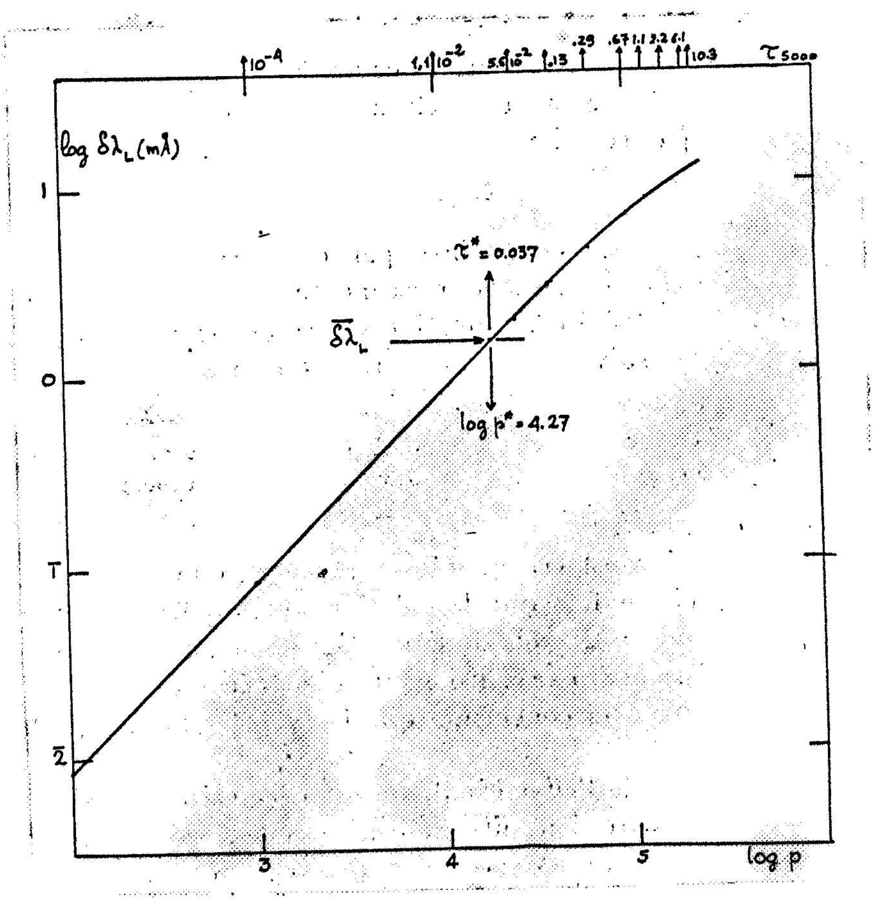

Figure 1.

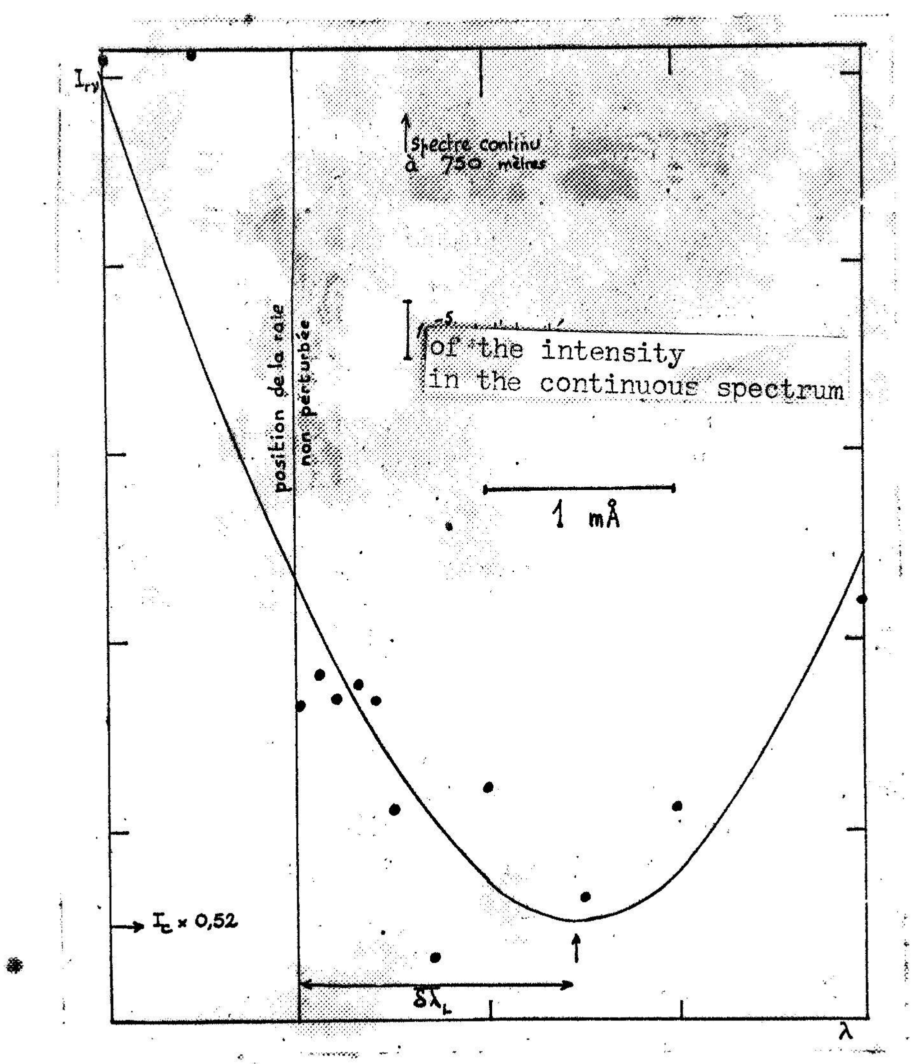

Figure 2.

We note that this figure represents, at an enormous scale, the background of the line considered (Mn 6013.50), and consequently, because of the improvements contributed by our method to the direct one, the scattering of the points around the curve drawn by means of least squares is rather slight. Computations with the aid of the IBM 650 now being performed, will contribute a still greater precision.

The resulting value of the Lindholm effect then is

$$\delta\lambda_L = 0{,}0015\,\text{Å},$$

which is inferior to Miss Adam's values.

Its formation depth (depth at which the local effect $\delta\lambda_L$ is equal to the resulting effect) then is

$$\tau_L^* = 0.037$$

This notion of average depth of Lindholm effect formation will be subsequently utilized to simplify the interpretations, even in the case when the Lindholm constant A is questionable, namely as regards its sign (Spitzer [4]).

**** END ****

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1. E. LINDHOLM. Ark. Math. Astrom, Phys., B, 28, No.3, 1941
2. M. G. M. MINNAERT, The Photosphere, in the Sun, Kuiper, Chicago U.P., 1952.
3. M. G. ADAM, M. N. R. A. S., 108, 1948, p. 459
4. L. SPITZER, ibid. 110, 1950, p.216.

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